RADTRAD – Past, Present, and Future

W. Arcieri, ISL, Inc.

Kerstun Norman, NRC Contracting Officer's Representative
Mark Blumberg, NRC Technical Monitor

Presented at
Fall 2019 RAMP Meeting
NRC Headquarters
Rockville, MD
October 28 to November 1 2019

Objective

- The purpose is to present an overview of the development of SNAP/RADTRAD including the history, present status and future plans.

Purpose of SNAP/RADTRAD

- Purpose of SNAP/RADTRAD is to determine the dose from a release of radionuclides during a design basis accident to the following locations:
  - Exclusion Area Boundary (EAB)
  - Low Population Zone (LPZ)
  - Control Room (or Emergency Offsite Facility)

- Focus of SNAP/RADTRAD is licensing analysis to show compliance with nuclear plant siting and control room dose limits for various LOCA and non-LOCA accidents.

Background of SNAP/RADTAD

About 10 years ago, NRC decided to incorporate RADTRAD into the SNAP graphical user interface due to maintenance difficulties:

- RADTRAD 3.10 was translated into JAVA from Fortran.
- Additional output (text based) was incorporated into SNAP/RADTRAD.
- The original Visual Basic GUI was converted to a SNAP plugin to provide GUI capability for developing RADTRAD models. Input checking was incorporated.
- Initial verification and validation was done on SNAP/RADTRAD.
- RADTRAD 3.03 status change to a legacy code with distribution by Radiation Safety Information Computation Center (RSICC) (https://rsicc.ornl.gov).

Background of SNAP/RADTAD

SNAP/RADTRAD is currently being used both domestically at the NRC and at licensee organizations as well as internationally.

- SNAP/RADTRAD is available to any organization that is a member of RAMP.
  - Membership privileges include access to the latest code executables, documentation on the use of the code and test reports.
- SNAP/RADTRAD training was provided in 2014 through 2018 either at the NRC or internationally (South Africa, Taiwan, UAE)
- NRC is continuing development and maintenance of both the SNAP GUI and the RADTRAD code.

Current Status

SNAP/RADTRAD is distributed in separate program packages:

- SNAP with the RADTRAD plug-in – basically the graphical user interface package. Maintained by Applied Programming Technology, Inc.
  - The RADTRAD plug-in provides the code to allow RADTRAD-specific features to be displayed in the SNAP Model Editor.
  - Default data used in RADTRAD is also programmed into the RADTRAD plug-in code.
- RADTRAD-AC – the RADTRAD analytical code (AC) that performs the actual radionuclide conventrations and dose calculations. Maintained by ISL, Inc.
  - Input files used by RADTRAD are exported by the Model Editor plugin.
- APTPlot – a plotting package that permits the user to plot dose results. Maintained by Applied Programming Technology, Inc.

Current Status

Other Changes made to the SNAP/RADTRAD code package:

- The entire ICRP-38 radionuclide set has been incorporated into SNAP/RADTRAD.
  - The user can make changes to the radionuclide library through the Model Editor, but usually not necessary.
- The ICRP-30 dose conversion factor library tabulated in the Federal Guidance Report No. 11 and No.12 published by the U.S. Environmental Protection Agency (EPA) has been incorporated into SNAP/RADTRAD.
  - User can specify DCFs if desired through the SNAP interface.

Current Status

- The ability to model non-LOCA accidents has been made easier:
  - Source term models for fuel handing accidents, rod ejection or control rod drop accidents have been added based on guidance in NRC Regulatory Guide 1.183.
  - Models for determining the reactor coolant inventory activity have been added so that tube ruptures and other reactor coolant related accidents can be modeled. Pre-incident and co-incident iodine spiking can be modeled.

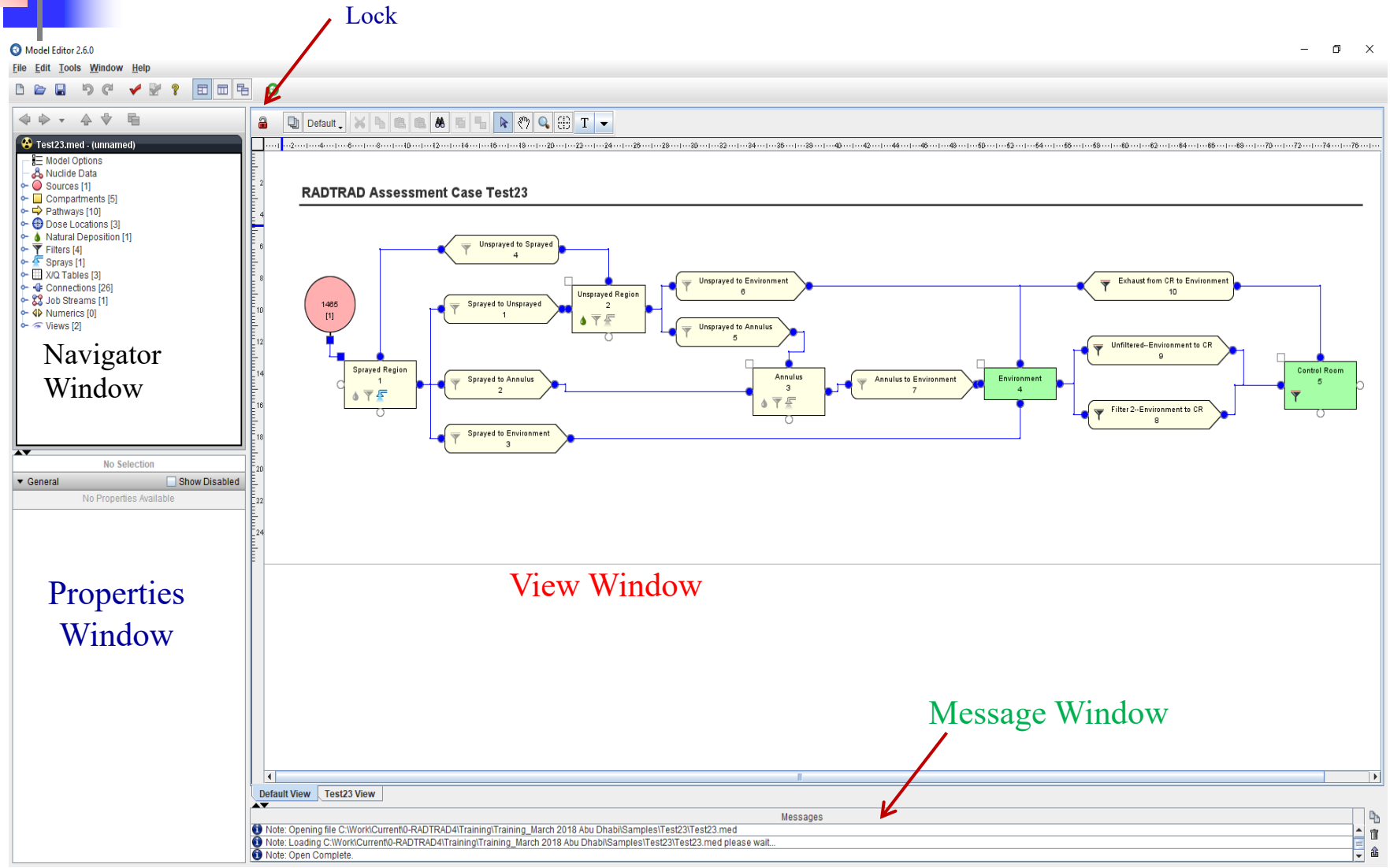
Current Status

- Other features in the SNAP/RADTRAD code package::
  - Multiple source terms can be analyzed
  - Multiple release pathways can be analyzed
  - Plotting of results through APTPlot available
  - Other SNAP features (Ex. multiple problems, parameter variation, model comparison) are available.
- Removal models (natural deposition, sprays, filters) are generally unchanged from earlier RADTRAD versions (V3.03).

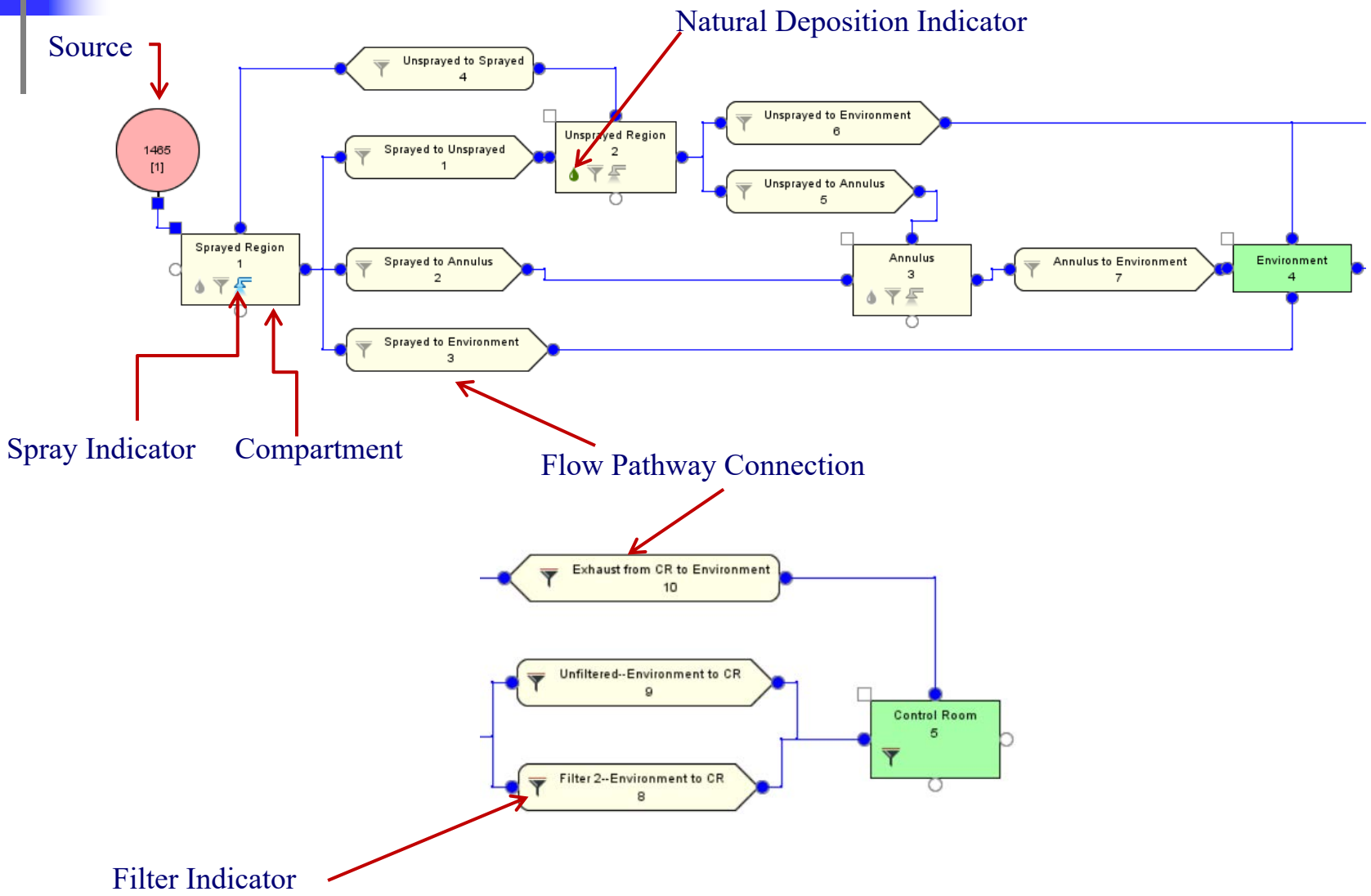
SNAP/RADTRAD Model Editor

- SNAP/RADTRAD input specification revolves around the use of the SNAP Model Editor
  - Up-to-date input specification with drag and drop interface
  - Good input error checking features
- Model Editor presents a standard interface across a large number of NRC codes.
  - Codes include TRACE and MELCOR, SCALE among others

SNAP/RADTRAD Model Editor (Test 23)



SNAP/RADTRAD Model Editor (Test 23)



SNAP/RADTRAD Model Editor (Test 23)

Current Model

Categories

Connections

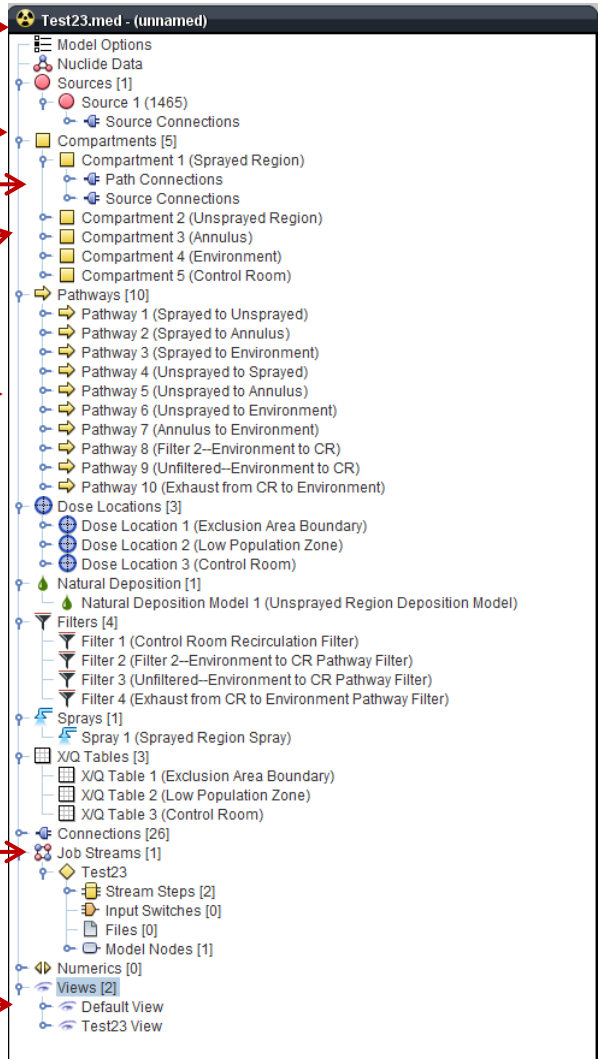
Compartments

Pathways

Component Navigator Window

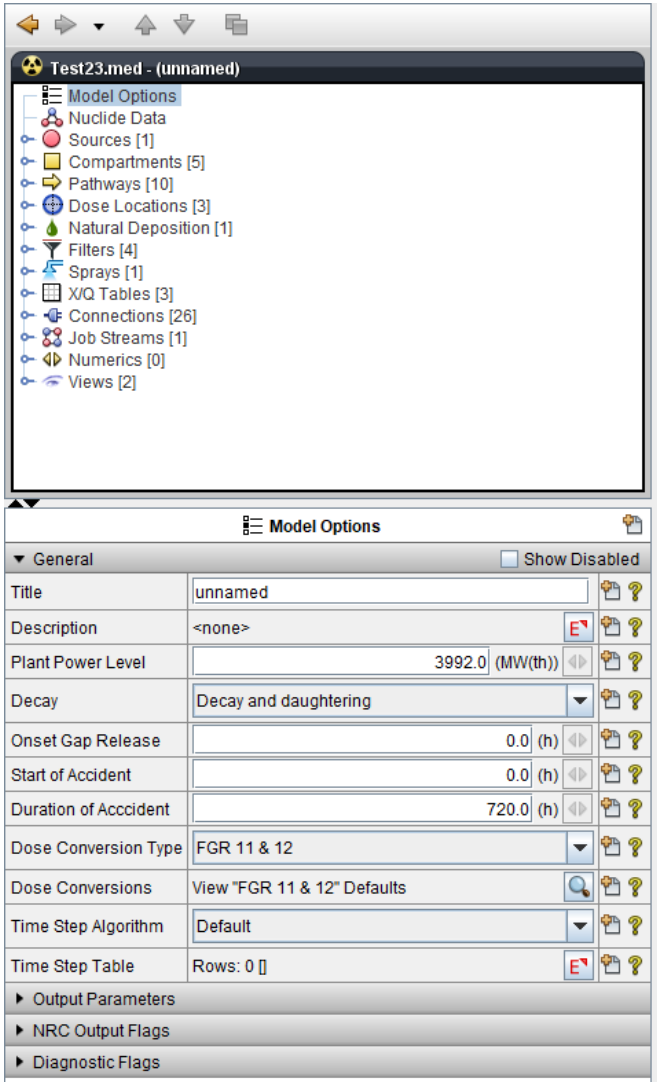
Job Streams

2D Views

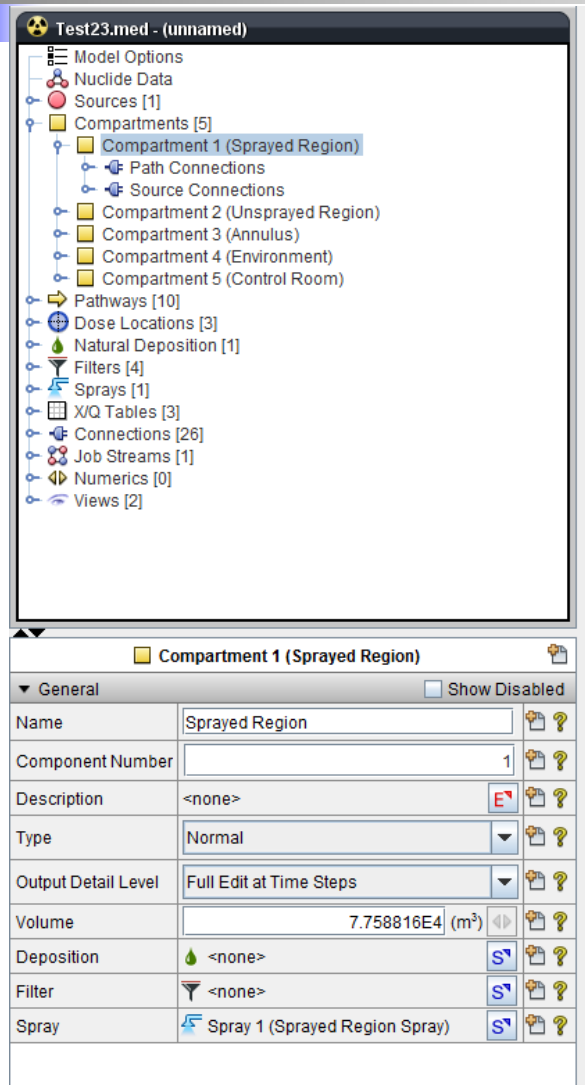


SNAP/RADTRAD Model Editor (Test 23)

General Model Options

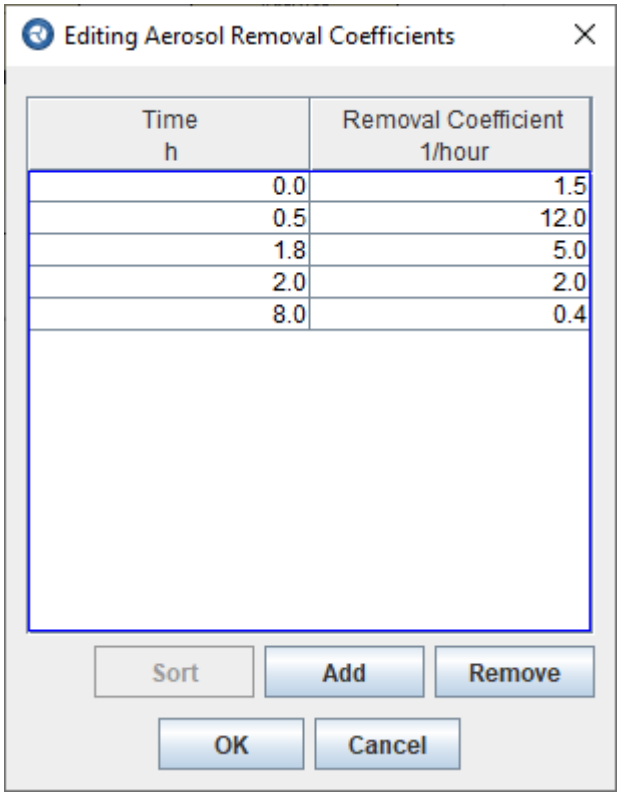


SNAP/RADTRAD Model Editor (Test 23)



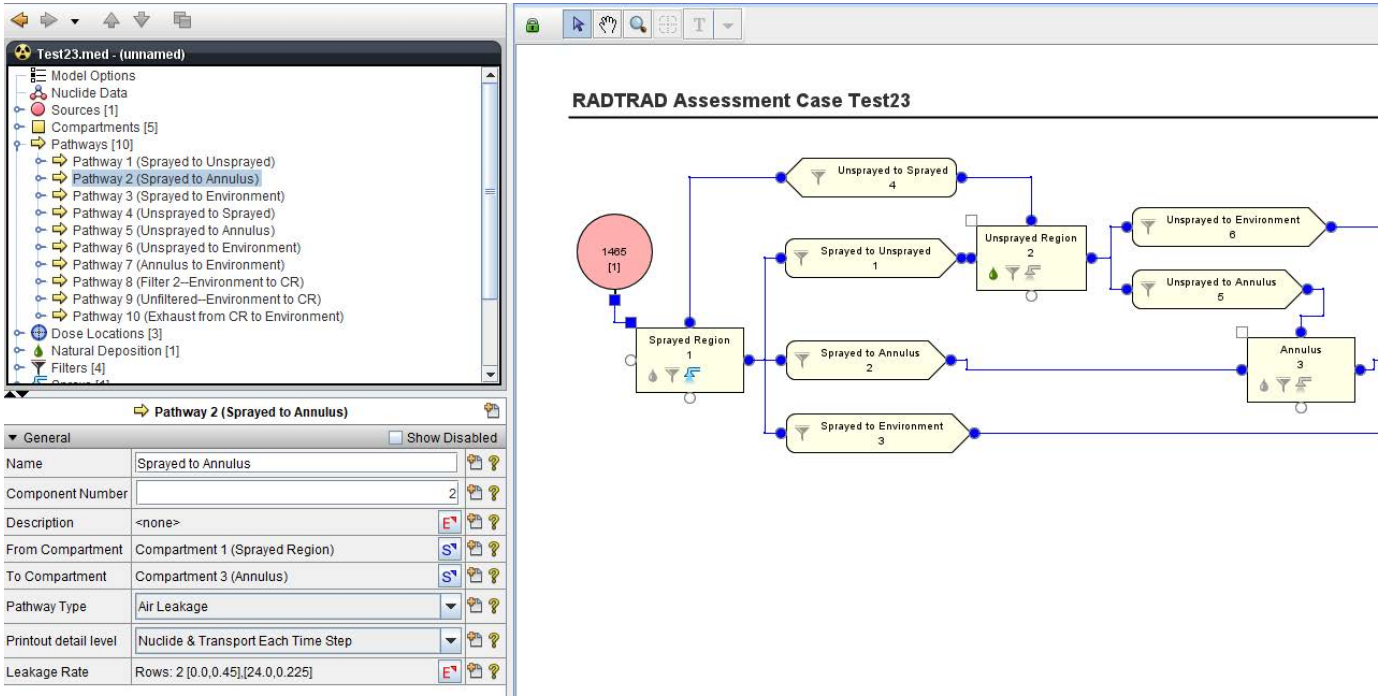
Navigator Window

Properties Window



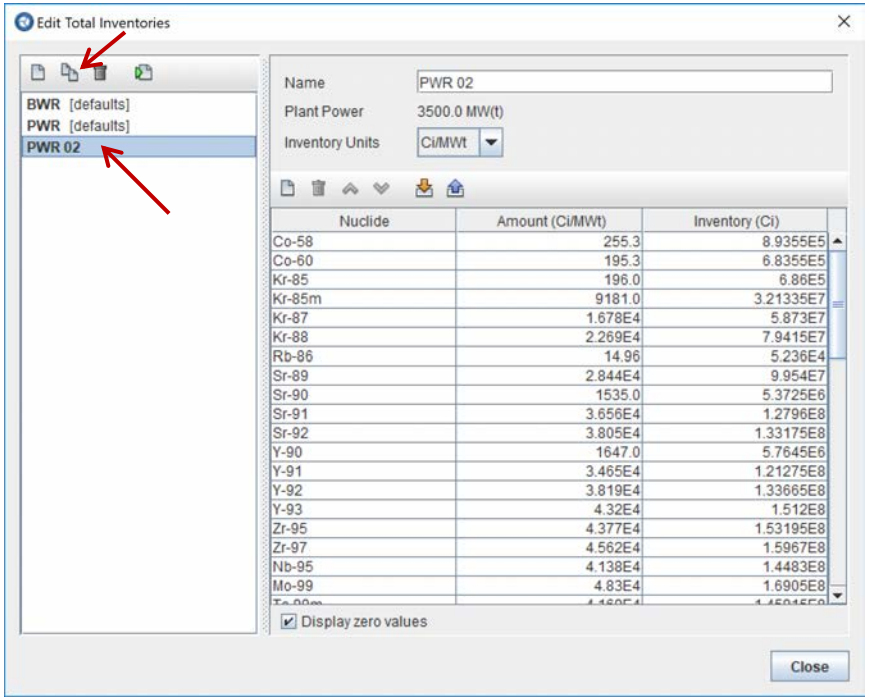
Typical Input Entry Window

SNAP/RADTRAD Model Editor (Test 23)

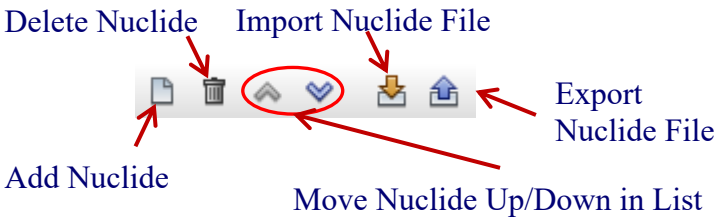


Flow Pathway Input

SNAP/RADTRAD Model Editor (Test 23)

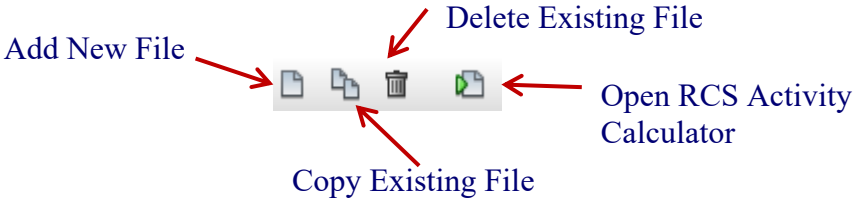


Nuclide Editing Icons

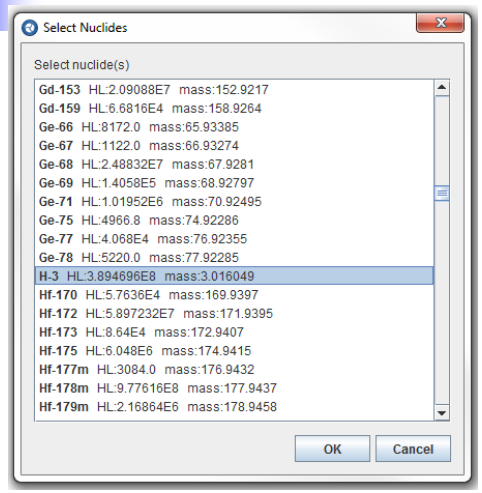


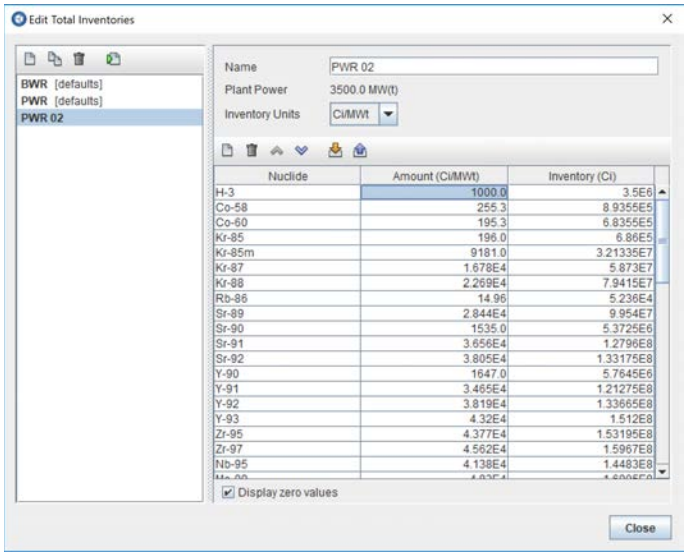
- The user can also add a new file clicking on the Add New File.

File Editing Icons

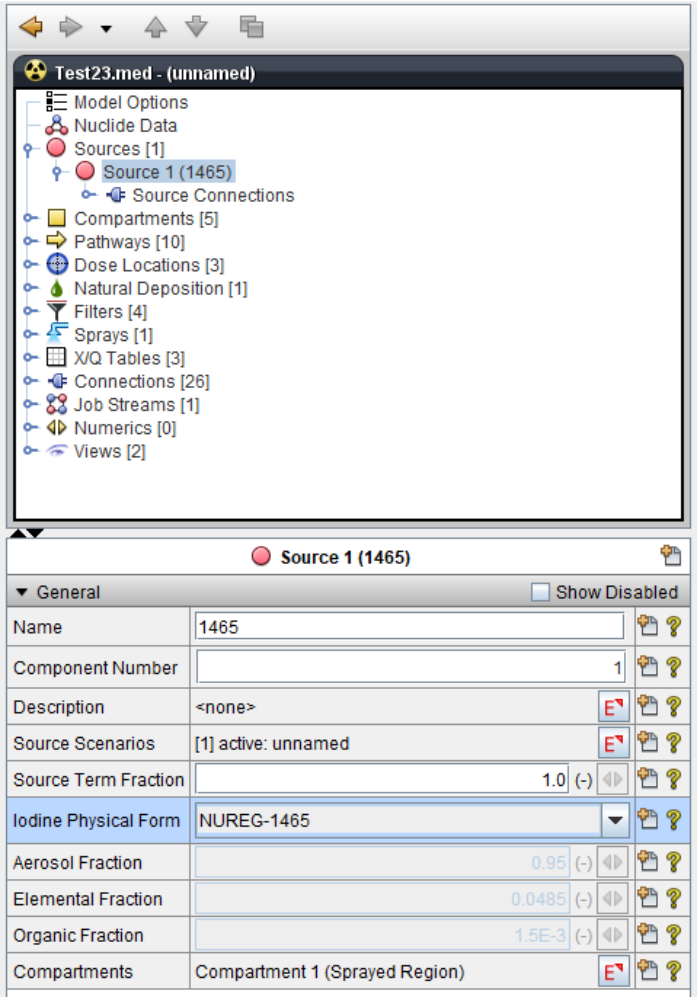


SNAP/RADTRAD Model Editor (Test 23)



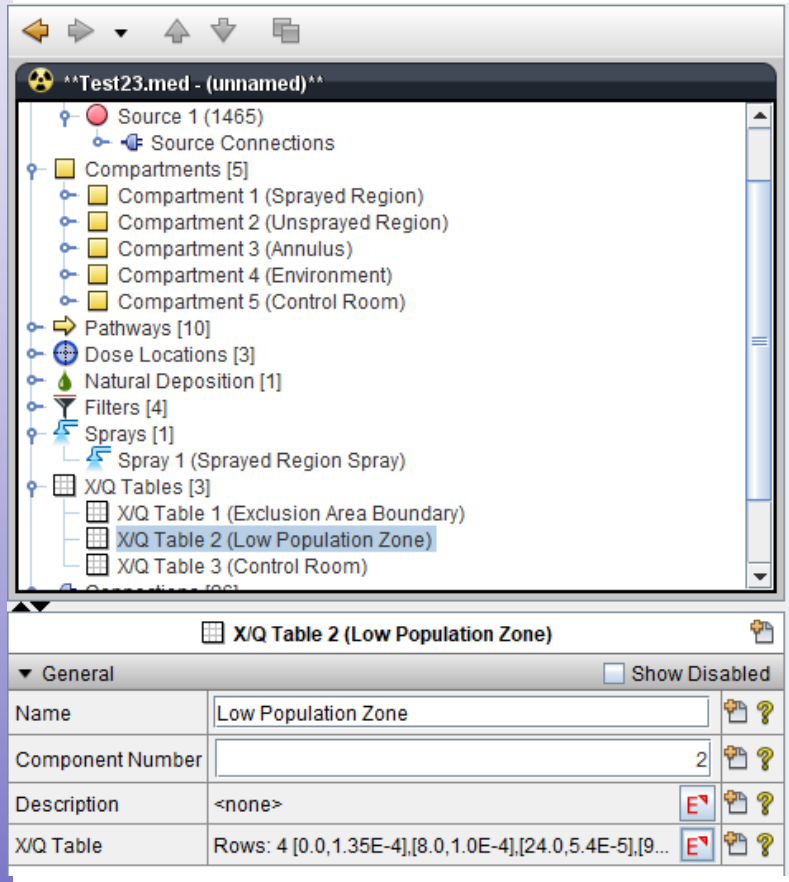


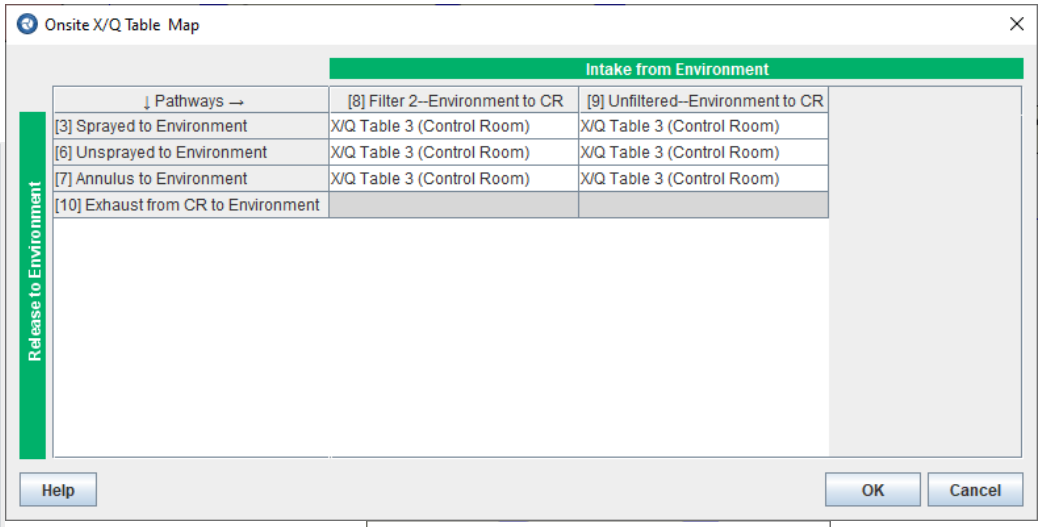
Nuclide Input

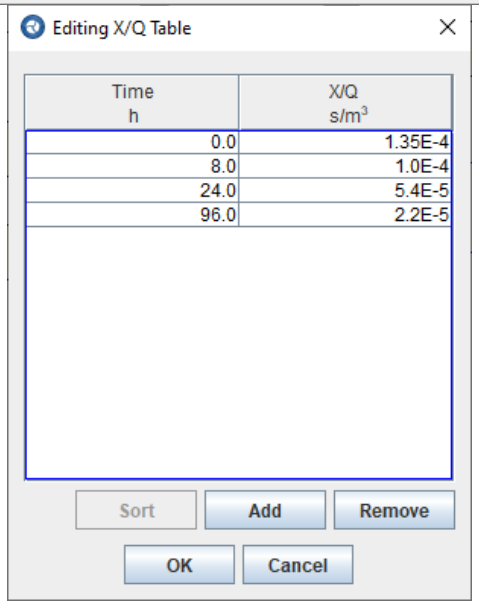


Source Location and Chemical Form Input

SNAP/RADTRAD Model Editor (Test 23)

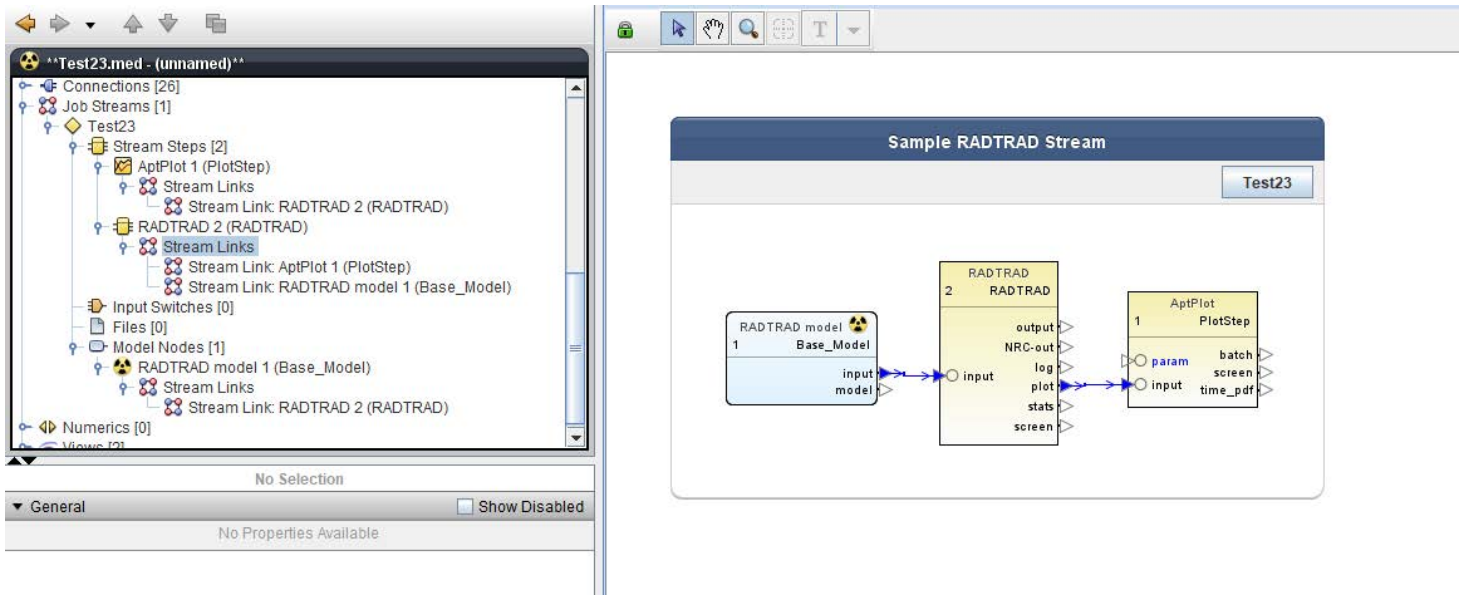






X/Q Input

SNAP/RADTRAD Model Editor (Test 23)



SNAP/RADTRAD Testing

- Testing was done on SNAP/RADTRAD by developing problem sets and running them with SNAP/RADTRAD. Then, a mathematical model of the same problem was programmed into Mathcad and the results compared.
  - Mathcad Version 14 used.
  - Generally relied on the AdamsBDF solver in Mathcad.
  - Interfaces with spreadsheets for problem input, radionuclide data and dose conversion factors used.
  - Comparisons made in terms of relative error. Calculations of maximum, minimum, averages of the error along with plots and results inspections used to judge the fidelity of the results.

SNAP/RADTRAD Testing

Over 60 RADTRAD problems tested. Scope of testing includes:

- Inter-compartmental Transfer
- Production Processes – TID-14844 and NUREG-1465 release models, ICRP-38 DCFs with corresponding FGR11&12 DCFs
- Decay – with and without daughters, release delay
- Removal within a compartment – aerosols (user-specified removal rates, Henry's model, Power's model)
- Removal within a compartment – elemental iodine (user-specified removal rates, Power's model)

SNAP/RADTRAD Testing

Over 60 RADTRAD problems tested. Scope of testing includes:

- Removal Processes – Flow Pathways – filters, piping (user-specified removal coefficients, Brockman/Bixler model)
- Control Room – intake/exhaust from environment, internal recirculation with filtration, flow pathway filtration
- Multiple source terms, multiple compartment pathways
- Various source term models – fuel handling accident, steam generator tube rupture, tritium release, rod ejection/control rod drop accident

SNAP/RADTRAD Testing

- Error Results for the Exclusion Area Boundary Based on Dose Results

	Error Range (%)			
	EAB		EAB	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error (%)	3.59	1.24E-03	3.63	1.56E-03
Min Error (%)	1.78	8.38E-06	2.88	2.61E-06

- Error Results for the Low Population Zone Based on Dose Results

	Error Range (%)			
	LPZ		LPZ	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error Range (%)	5.38	3.34E-03	5.38	3.17E-03
Min Error Range (%)	1.78	1.70E-06	2.88	2.36E-06

SNAP/RADTRAD Testing

- Error Results for the Control Room Based on Dose Results

	Error Range (%)			
	Control Room		Control Room	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error Range (%)	9.95	2.64E-01	13.75	3.20E-01
Min Error Range (%)	0.94	2.92E-05	1.03	2.92E-05

SNAP/RADTRAD Testing

- Overall Averages based on Dose Results Comparisons:

	Average of Averages (%)	
	EAB	EAB
	Thyroid	TEDE
Avg Error (%)	0.41	0.54
	LPZ	LPZ
	Thyroid	TEDE
Avg Error (%)	0.42	0.49
	CR	CR
	Thyroid	TEDE
Avg Error (%)	0.49	0.49

Future Plans

- Continue to resolve issues raised by users.
- Features that may be incorporated into future versions:
  - Better specification of input for problems involving reactor coolant
    - Currently volume units are used (ft^3, ft^3/min). Works because f/V (1/hr) is the key parameter.
    - Mass units would be more convenient
    - Make the use of user-specified RCS activities more apparent
  - Update to current standards:
    - Ex: ANS/18.1 for the specification of RCS coolant activity was reactivated.
    - Standards should be consistent across codes used in RAMP (ex. GALE).

Future Plans

- Features that may be incorporated into future versions:
  - Updated dose conversion factors possibly based on ICRP 103
  - Improve performance of adaptive time stepping algorithm
  - Integrate the original and NRC output files
  - Automatic interface with other RAMP codes possibly using spreadsheets generated as part of the output.